(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 325 449**
**A2**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **89300490.3**

(22) Date of filing: **19.01.89**

(51) Int. Cl.4: **G 01 N 33/543**
G 01 N 33/74, G 01 N 33/58

(30) Priority: **19.01.88 US 145522**

(43) Date of publication of application:
**26.07.89 Bulletin 89/30**

(84) Designated Contracting States:
**AT BE CH DE FR GB IT LI NL SE**

(71) Applicant: **IDEXX CORP.**
**100 Fore Street**
**Portland Maine 04101 (US)**

(72) Inventor: **McMahon, Philip**
**45 Winn Road**
**Falmouth Maine (US)**

**Tonelli,Quentin**
**37 Wellington Road**
**Portland Maine (US)**

**Chaney, Larry**
**45 Austin Street**
**Portland Maine (US)**

(74) Representative: **Hitchcock, Esmond Antony et al**
**Lloyd Wise, Tregear & Co. Norman House 105-109 Strand**
**London WC2R 0AE (GB)**

(54) **Immunoassays.**

(57) In one aspect, a kit for the semi-quantitative measurement, in a liquid sample, by competitive immunoassay, of a first member of a specific binding pair, the kit including a solid support bearing
a reference area which provides a detectable signal in the immunoassay, and
a first and a second test area exposed to contact a sample, each test area containing a different amount of second or first member of the specific binding pair,
whereby the intensity of the detectable signal from the reference area can be compared with the intensity of any detectable signals from the first and second test areas in the presence of an unknown quantity of the first member in the sample.

EP 0 325 449 A2

## Description

# IMMUNOASSAYS

This invention relates to immunoassay methods for the detection or measurement of substances in liquid samples, e.g., biological fluids such as whole blood, serum, plasma, and urine.

A wide variety of substances are commonly detected or measured by immunoassay methods in biological samples; examples are hormones, antibodies, toxins, and drugs. Usually, although not always, either the substance being detected, or a substance used in its detection, is an antibody, hence the term "immunoassay". The antibody is a member of a specific binding pair, the other member of the pair being referred as an antigen or analyte. Other specific binding pairs, besides antibody-antigen pairs, which are measured and used in immunoassays, include pairs of molecules which have specific binding affinity for each other, e.g., hormones - hormone receptors, and biotin-avidin.

Immunoassays are commonly carried out, at least in part, on solid supports, e.g., glass fiber membranes. The two most common formats for immunoassays employing solid supports are competitive and sandwich formats. In a typical competitive assay, the substance to be measured (the analyte) is a low molecular weight substance such as a drug residue or small hormone, with a molecular weight from about 100 to about 2,000; such low molecular weight substances do not easily lend themselves to sandwich assays, described below. In the typical competitive assay, an antibody to the analyte is immobilized on a solid support, and the sample suspected of containing the analyte is brought into contact with that solid support. At the same or a later time, a liquid solution containing labeled analyte is contacted with the support, so that the labeled analyte and any analyte in the sample compete for binding to the immobolized antibody. (If the substance being measured is itself an antibody, the immobilized analyte can be either antibody to that antibody , or an antigen for which that antibody is specific.) The solid support is then washed and the amount of label measured or detected as an inverse measure of analyte in the sample. Typically, the label is a chemiluminescent substance, a radioisotope, or, most preferably, an enzyme which, in the final step, reacts with a chromogenic substrate, which develops color of intensity inversely related to the amount of analyte present in the sample. A typical competitive format is described, e.g., in Litman et al. U. S. Patent No. 4,540,659, hereby incorporated by reference. In the Litman et al. competitive assay, in addition to the test spot, the solid support also bears what Litman et al. refer to as a "calibration surface" which, preferably, but not necessarily, contains antibody to the substance being measured, and serves as "a standard for the evaluation for the signal level of the measurement surface" (columm 3, lines 14 through 17).

Sandwich immunoassays (e.g., as described in David et al. U. S. Patent No. 4,376,110, hereby incorporated by reference) generally are used to detect or measure substances (again, analytes) of molecular weights above 2,000, e.g., antibodies and other proteins. In a typical sandwich assay, a first antibody to the analyte is immobilized on a solid support, which is then contacted with the liquid sample so that any analyte in the sample binds to the antibody. A second labeled antibody to the analyte is then added, the support is washed, and the amount of bound label is measured, bound label being proportional to the amount of analyte in the sample.

A goal of some immunoassays has been a result which is not simply a positive or negative, but which is semiquantitative, i.e., provides a rough, not totally precise estimate of the amount of analyte present in the sample. For example, Chandler et al., International Archives of Allergy and Applied Immunology 72, 267, 1983 describes a semiquantitative immunoassay for IgE in plasma employing three glass capillary tubes, each bearing immobilized antibody specific for IgE. Swanljung European Patent Application No. W085/02466 describes a colorimetric immunoassay in which the test color is compared to reference colors to provide a semiquantitative result. Litman et al., above, states that "one can quantitate the observed results in relation to ratios obtained with known amounts of the analyte and graphing the change in ratio of signal level with change in concentration."

There are a number of aspects of the present invention which provide immunoassays which are superior to prior assays in various ways.

In one aspect, the invention features a kit for the semiquantitative measurement, in a liquid sample, by competitive immunoassay, of a first member of a specific binding pair. The kit includes a solid support which bears a reference area which provides a detectable signal in the immunoassay, as well as a first and second test area, each of which contains a different amount of first or second member of the specific binding pair, whereby the intensity of the detectable signal from the reference area can be compared with the intensity of any detectable signals from the two test areas in the presence of an unknown quantity of the first binding pair member in the sample. The two amounts of binding pair member on the test areas are preferably selected so that the first area, but not the second area, generates a detectable signal of significantly lower intensity than that of the reference area (i.e., can be distinguished from the reference area by eye, without the need for instruments) when the sample contains a first amount of the first member of the specific binding pair, while both areas generate detectable signals significantly lower in intensity than that of the reference area when the sample contains a second, greater amount of the first member of the specific binding pair. Preferably, the intensity of the signal generated by the first test area varies in substantially linear fashion when the sample contains the first member of the specific binding pair in an amount within a first range, and the intensity of

the signal generated by the second test area varies in substantially linear fashion when the sample contains the first member of the specific binding pair in an amount within a second, greater range. The two test areas are best able to exhibit this desired linear response to different ranges when the amounts of binding pair member in the test areas are selected so that the first test area is saturated when the sample contains the first member of the specific binding pair in a first amount and the second test area is not saturated at that first amount, but is saturated at a second, higher amount. If a wide range of amounts of the first member of the specific binding pair are of interest, the solid support can, of course, bear more than two test areas, each of which will, by virtue of its containing a different amount of binding pair member, have a different maximum binding capacity for the first member, and thus a different linear range.

The competitive test can have two configurations. In one, the support test areas bear second binding pair member (e.g., antibody or receptor protein), and labeled and sample first member compete for binding to test areas. In the second configuration, the test areas bear first binding member which competes with first binding member in the sample for binding to the labeled second binding member; first binding member in the sample binds labeled second member, decreasing its signal-producing binding to the test areas.

The competitive immunoassay of the invention provides semiquantitative results without the need to run standards and compare a test result to such standards. Furthermore, the assay enables the semiquantitative result to be obtained with only one addition of sample to the test apparatus, providing a simple, convenient test procedure. In addition, where, as is preferred, the label used is an enzyme, which reacts with a chromogenic substrate, the semiquantitative result can be read by eye, without the need for a radioisotope counter or other apparatus.

In another, related aspect, the invention provides a kit for the determination, by competitive immunoassay, of the presence in a liquid sample of an amount greater than or equal to a predetermined, physiologically significant amount of a first member of a specific binding pair. The kit includes a solid support which, like the support discussed in connection with the first aspect of the invention, above, bears a reference area which provides a detectable signal in the immunoassay, as well as a test area adapted to generate a detectable signal of lesser intensity with greater concentrations of first binding pair member in the sample, and containing the first or second member of the specific binding pair in an amount which, in the immunoassay, causes the test area to generate a detectable signal of significantly lower intensity than that of the reference area when the first member of the specific binding pair is present in the sample in an amount equal to or greater than a predetermined, physiologically significant amount, and which does not, in the immunoassay, cause the test area to generate a signal of significantly lower intensity from that of the reference area when the first specific binding member is present in the sample in an amount below that predetermined, physiologically significant amount. A signal which has a "significantly lower intensity" than that of the reference signal is one which can be detected visually by a human user of the test, without the use of measurement instruments. This aspect of the invention has the greatest utility in the detection of physiologically important threshhold levels of such substances as toxins and drugs, which might be harmless in small amounts and are of interest only if present in greater than a predetermined minimum amount. As in the multiple spot competitive test described above, the test area can bear either first or second binding pair member.

In both aspects of the invention, above, the kit preferably futher includes labeled first or second member of the specific binding pair, depending on which binding pair member is immobilized in the test areas. Most preferably, labeling is by means of an enzyme which acts on a chromogenic substrate to produce a color change, and the reference area contains antibody to the enzyme, but does not contain any first or second member of the specific binding pair, and thus becomes colored in every test by virtue of the enzyme-labeled first or second binding pair member's binding to the anti-enzyme antibody in the reference area. Because the reference area does not contain the first or second member of the specific binding pair, its color change is independent of the amount of first specific binding member present in the sample. Further, the reference area provides control for batch to batch variations in enzyme and chromogenic substrate, because its color change, like the color changes of the test areas, is a product of the action of those reagents.

In another aspect, the invention provides a kit for the semiquantitative measurement in a liquid sample, by sandwich immunoassay, of an analyte, e.g., an antibody or other protein. The kit includes a solid support bearing a test area containing a first antibody specific for the analyte, and a first and second calibration area, each of which contains a different amount of the analyte being tested for, whereby the intensity of the detectable signal from the test area can be compared with the intensity of the detectable signal from the first and second calibration areas in the presence of an unknown quantity of analyte in the sample. Preferably the kit further includes a labeled second antibody specific for the analyte, so that, on the test area, a conventional labeled sandwich is formed when the analyte is present in the sample. The reference areas bind labeled antibody independently of the presence or level of analyte in the sample. Furthermore, each reference area, by virtue of its different amount of analyte, has a binding capacity for labeled antibody different from the others, and thus each is saturated at a different level. Thus, a semiquantitative result can be obtained; the test area is compared to the reference areas, each of which represents a range of analyte; it can thus be determined that the sample contains an amount of analyte in the range of the maximum binding capacity of the reference area

which matches the test area. The sandwich assay of the invention is thus useful where it is important to know not simply whether an analyte is present in a sample, but to know its approximate quantity. This assay, like the above described competitive assay, permits this semiquantitative result to be obtained with the use of only one sample in one test kit apparatus.

In another aspect, the invention features an alternative kit for the semiquantitative measurement, in a liquid sample, by sandwich immunoassay, of an analyte. The kit includes a solid support bearing a first and second test area, each of which contains a different amount of a first antibody specific for the analyte, whereby the presence in the sample of the analyte in a first amount causes a substantial change in signal intensity (development of a signal which is greater than 50% of the signal the test area could develop in the presence of unlimited analyte) in the first but not the second test area, and the presence in the sample of the analyte in a second, greater amount causes a substantial change in signal intensity in both first and second test areas. Preferably, the kit further includes an enzyme-labeled second antibody to the analyte.

Other features and advantages of the invention will be apparent from the following description of preferred embodiments thereof, in which reference will be made to the accompanying drawings wherein;

Fig. 1 is an exploded prospective view of apparatus for use of the invention.

Fig. 2 is a diagrammatic representation of a solid support (18, Fig. 1) of the invention, for use in a competitive immunoassay, bearing a reference area and three test areas.

Fig. 3 is a diagrammatic representation of the response of the solid support of Fig. 2 to various concentrations a substance in a sample.

Fig. 4 is a graph illustrating the response of the three test areas of the support of Fig. 2 to varying concentrations of a substance (equine progesterone).

Fig. 5 is a diagrammatic representation of a membrane for use in a sandwich immunoassay of the invention.

Fig. 6 is a diagrammatic representation of assay results obtained using the membrane of Fig. 5.

Fig. 7 is a diagrammatic representation of a membrane, for use in a sandwich immunoassay of the invention.

Fig. 8 is a digrammatic representation of assay results obtained using the membrane of Fig. 7.

Competitive Immunoassay Apparatus

Referring to Fig. 1, test apparatus 10 is generally of the configuration described in U.S. Patent No. 4,376,110, hereby incorporated by reference. Apparatus 10, adapted for the measurement of progesterone in mare serum, includes plastic cup 12 in which there is placed plug 14, comprising absorbant material supplied by American Filtrona Corporation, supporting porous polyethylene disk 16, and glass fiber membrane 18 (pore size 1 micron, obtained from Gelman Sciences). Pre-filter 26 (the same as membrane 18) is positioned between test membrane 18 and plastic lid 30. Filter 26 is removable so that test results can be read on test membrane 18. Auxilliary to apparatus 10 is sponge means 32, comprising sponge plug and handle 36. Sponge 32 serves the function of seating pre-wetted membrane 18 at the start of the assay.

Referring to Fig. 2, membrane 18 bears reference spot C and, when a semiquantitative assay is to be carried out, multiple test spots 1, 2 and 3, each of which contains a different concentration of latex particles coated with anti-equine progesterone monoclonal antibody (Immunosearch, Toms River, N.J.). For loading, polystyrene latex particles are suspended in phosphate buffer containing the antibody, washed, and then resuspended in phosphate buffer for spotting onto membrane 18. Each antibody coated particle preparation, prior to spotting, is diluted with latex particles coated with the inert protein bovine serum albumin (BSA), so that the percent antibody particles on the spots are: spot 1, 60%; spot 2, 50%, and spot 3, 40%. The concentrations of antibody are selected such that spot 1 is saturated when the serum sample contains one ng/ml of progesterone, spot 2 is saturated at 5 ng/ml, and spot 3 is saturated at 10 ng/ml. Where the assay, rather than being semi-quantitative (as defined above), is for the purpose of determining whether or not progesterone is present in a sample in an amount greater than a physiologically significant amount (e.g., 4 ng/ml); membrane 18 bears only one test spot, which undergoes significant color intensity change only when progesterone is present in the sample in an amount greater than that physiologically significant level. Reference spot C contains latex particles coated, as above, with antibody to the enzyme label, horseradish peroxidase (HRP) (Accurate Chemicals). Located above reference spot C is orientation dot 24. As an alternative to using latex particles, the antibodies can be spotted directly onto the membrane either passively adsorbed, or by chemical cross-linking.

Operation of Semiquantitative Competitive Assay

Referring again to Fig. 1, membrane 18 is pre-wetted with several drops of wash solution containing 0.25 - 1M sodium chloride, 2% dry milk, 5% bovine serum albumin, and preservatives. Ten to fifteen drops of serum are then applied to membrane 18 and allowed to react for five minutes to permit any progesterone present in the sample to bind to the antibody in test spots one, two, and three. Cap 30 and pre-filter 26 are then removed and wash solution is added, and then three to four drops of HRP-labeled progesterone (Sigma Chemical Co., St. Louis, MO) are added; this labeled analyte binds to any antibody on test spots one, two, and three not bound to progesterone in the sample. The labeled progesterone is allowed to react for one minute, the membrane is again washed with wash solution, and then three to four drops of the chromagenic substrate tetramethylbenzidine are added and allowed to react, developing color, for one minute. There are then added ten to fifteen drops of standard stop solution, completing the assay.

Fig. 3 illustrates the results of tests carried out

with solutions containing four different, progressively greater concentrations of equine progesterone. In each of the seven membranes shown, spot C has undergone the same degree of color change, independently of the concentration of progesterone in the sample. In membrane A, treated with sample containing less that one unit (1 ng/ml) of progesterone, reference spot C is lighter that all three test spots. In membrane B, treated with sample containing one unit of progesterone, reference spot C exhibits the same color as test spot one, but is lighter than spots two and three. Membrane C, treated with sample containing between one and five units of progesterone, shows spot C lighter than spots one and two but darker than spot three. In membrane D, treated with sample containing five units of progesterone, reference spot C has the same color intensity as spot two, is darker than spot one, and lighter than spot three. In membrane E, treated with sample containing between five and ten units of progesterone, spot C is darker that spot one and two but lighter than spot three. In membrane F, treated with sample containing ten units of progesterone, spot C is equal in intensity to spot three, but darker than spots one and two. In membrane G, treated with sample containing more than ten units of progesterone, spot C is darker than all three test spots.

The capacity of test spots one, two and three to react differently to the same concentration of progesterone is illustrated in Fig. 4, which shows that, for each spot, a different concentration of progestrone in the sample is required to produce a linear decrease in color intensity. Fig. 4 shows that test spot one contains sufficient antibody such that the color intensity drop from fifty to twenty units is substantially linear over a concentration of one to five ng/ml of progestrone; the color intensity drop from fifty to twenty units of test spot two is substantially linear over a progestrone concentration of between five and ten ng/ml; and a color intensity drop from fifty to twenty units for test spot three is substantially linear for progestrone concentrations between ten and fifteen ng/ml.

Thus comparison of the color intensity of the test spots with that of the reference spot provides a semiquantitative indication of the amount of progesterone in the test sample. This is of great importance for this hormone, because its level serves as an indication of estrus and also of maintenance of pregnancy in horses. In the case of a pregnant mare, a serum progesterone level above about 4 ng/ml indicates that pregnancy is being maintained, while a level below 4ng/ml indicates that there may be a problem with pregnancy maintenance, and corrective action may be required. In the case of a mare which is not pregnant, a serum progesterone level below about 1 ng/ml indicates estrus, i.e., that the mare is ready for breeding. In addition to these general principles, because every mare has its own distinctive physiology, it is important, for any given breeding mare, to follow progesterone levels over time, to obtain a historical profile of the hormone cycling of that mare, so that impregnation and pregnancy maintanence can be optimized.

As mentioned above, the test spots can contain progesterase rather than antibody, in which case labeled antibody to progesterone is used.

Operation of Single Spot Competitive Assay

Where membrane 18 bears only one test spot, containing progesterone or anit-progesterone antibody in an amount such that it undergoes significant color change only when the progesterone level in the sample is above a physiologically significant level, the assay is carried out as described above, except that membrane 18 bears only one test spot.

Sandwich Immunoassay Apparatus

The apparatus illustrated in Fig. 1 is also used in the sandwich assay, except that membrane 18 is replaced by membrane 38, shown in Fig. 5. Membrane 38 is adapted to provide a semiquantitative measure of equine IgG in foal serum. The apparatus, including membrane 38, is commercially available from Agritech Systems, Inc., 100 Fore Street, Portland, Maine, and is sold under the trademark CITE. Spot S on membrane 38, located below orientation dot 40, comprises latex particles coated with antibody to equine IgG (Jackson Immunoresearch, P.O. Box 683, Avondale, PA). Calibration spots 1, 2, and 3 contain no anti-IgG antibody, but do contain, respectively, horse IgG equivalent to the amount captured by spot S from a 200 mg/dl, 400 mg/dl, and 800 mg/dl sample, coated on latex particles. Antibody to equine IgG, which is also commercially available from a number of sources, is loaded onto the latex particle as described above for equine progesterone.

Operation of Semiquantitative Sandwich Assay

The appratus of Fig. 1, including membrane 38, is used in conjunction with serum, plasma, or anti-coagulated whole blood samples, drawn from foals. Because of variations in hematocrit among foals, it is most preferable to use serum or plasma, which can either be fresh or previously frozen. If whole blood is used, it must, prior to assay, be anti-coagulated with heparin, EDTA, or citrate. Hemolyzed samples may be used without the risk of false positives.

Two microliters of serum or plasma from a foal are drawn into a microtiter capillary pipet, and excess sample is wiped from the outside of the pipet. The sample is then inserted into a container containing standard phosphate buffer containing 5% BSA, as sample diluent, mixed, and ten drops of diluted sample are then added, via pipet, to the center of the assay apparatus of Fig. 1. The sample is permitted to react with membrane 38 for 3 minutes, after which time 4 drops of a solution containing a second anti-equine IgG antibody, conjugated to the enzyme alkaline phosphatase, are added. (Anti-equine IgG antibody conjugated with alkaline phosphatase is available from Jackson Immunoresearch, Avondale, PA.) This second, labelled antibody binds to any equine IgG captured by reference spot S and also binds to that previously coated on spots 1, 2, and 3. The reaction is allowed to proceed for 2 minutes, after which time 5 to 10 drops of wash solution (composition described above) are added. Con-

tainer 12 is then nearly filled with wash solution and, after the wash solution has been completely absorbed by absorbant 14 (at this point all of the blue color from the enzyme conjugate solution should be washed away), 4 drops of chromogenic substrate for alkaline phosphatase (indoxyl phosphate, JBL Scientific, CA) are added. The substrate solution is allowed to stand for 3 minutes so that color may fully develop, after which time membrane 38 is inspected so that the IgG level in the sample can be determined.

Fig. 6 illustrates the results obtained with six different concentrations of equine IgG. In each of the six membranes A through F, calibration spots 1, 2, and 3 have reacted in the same way, i.e. spot 1, corresponding to 200 mg/dl IgG, is the lightest, spot 2, corresponding to 400 mg/dl, is next lightest, and spot 3, corresponding to 800 mg/dl, is the darkest of the three; the intensity of each spot, as explained above, is independent of IgG concentration in the sample, as the spots contain IgG, but no antibody to IgG. In membrane A, the sample spot remains white or is lighter in color than calibration spot 1, indicating that the sample contains less than 200 mg/dl equine IgG; in membrane B, the sample spot is darker than calibration spot 1 but lighter than calibration spot 2, indicating an IgG concentration of between 200 and 400 mg/dl; in membrane C, the sample spot is equal in color intensity to calibration spot 2, indicating an IgG concentration of 400 mg/dl; in membrane D, the sample spot is darker than calibrations spot 2 but lighter than calibration spot 3, indicating an IgG concentration of between 400 and 800 mg/dl; in membrane E, the sample spot is equal in intensity spot 3, indicating an IgG concentration of 800 mg/dl; and in membrane F, the sample spot is darker than calibration spot 3 indicating an IgG concentration of greater than 800 mg/dl.

The illustrated test is of great importance in the monitoring of the immune status of foals, which are born with little or no circulating immunoglobulin. Neonatal immunity to infectious agents requires the uptake and absorption of maternal antibodies from colostrum. Failure of passive transfer can occur as a result of premature lactation, deficient suckling, mal-absorption , or low levels of IgG in colostrum. Partial or complete failure of immune transfer occurs in 10 to 25 percent of all foals, and these animals are at high risk of serious illness or death. Greater than 800 mg of IgG per 100 ml serum is considered an adequate level of immunity. Levels of between 400 and 800 mg/dl may be adequate, but foals at this level are possibly at risk. IgG levels between 200 and 400 mg/dl reflect a partial failure of immune transfer, while concentrations of less than 200 mg/dl suggest total failure. Rapid identification of low IgG levels is essential to the early initiation of treatment of immunodeficient foals. Furthermore, post-treatment testing allows a timely evaluation of the success of IgG supplementation.

Semiquantative Sandwich Immunoassay Apparatus (Alternate Configuration)

Referring to Fig. 7, an alternate semiquantative immunoassay employs the apparatus of Fig. 1, and in place of membrane 38 (Fig. 5) described above, membrane 42, which bears orientation dot 44, positive control spot C, and test spots 1 and 2; membrane 42 is adapted to be used to estimate IgG levels in foal serum. Test spot 1 contains about 60% latex particles coated with anti-equine IgG antibody (the other 40% are BSA-coated particles), while test spot 2 contains about 5% antibody-coated latex particles. Because of the high concentration of antibody on spot 1, favorable reaction kinetics will apply, and a substantial (greater than 50% of the potential) color reaction will develop even in the presence of less than 400 mg/dl IgG. Because of the unfavorable reaction kinetics resulting from the low antibody concentration on spot 2, a sample IgG concentration below 400mg/dl will not develop substantial color, and a higher concentration is required for such development.

Positive control spot C contains no antibody to foal IgG but only latex particles coated with antibody to HRP; the only function of spot 34 is to serve as an indicator that the chromogenic system is operative (absence of color in spot 34 indicates a defective assay).

Operation of Alternate Sandwich Immunoassay

The alternate sandwich immunoassay is carried out as described above for equine IgG, except that membrane 42 (Fig. 7) is used in place of membrane 38.

Typical results of the assay are shown in Fig. 8. In all 3 membranes A, B, and C, the positive control spot C bears a dark color, indicating that the assay reagents are operative. In membrane A, neither of test spots 1 and 2 has developed color, indicating the absence in the sample of foal IgG. In membrane B, test spot 1, which is heavily loaded with antibody, has developed a dark color, but test spot 2, bearing less antibody, has developed only a slight amount of color, indicating that some low level, e.g. on the order of <400 mg/dl, of IgG is present in the sample. In membrane C, both test spots 1 and 2 have developed a dark color, indicating that the sample contains a high concentration, e.g., above 400 mg/dl, of IgG.

Other Embodiments

Other embodiments are within the following claims. For example, in any of the above assays in which there are multiple reference, test, or calibration spots, there may be more spots than are illustrated in the examples. In addition, one support membrane can bear antigen or antibody appropriate for measurement of more than one analyte, so that, for example, two or more drugs, toxins, proteins, or antibodies can be detected all at the same time. Any of a variety of labels can be used, including machine-readable signal generating systems such as radioiostopes, although enzyme-chromogen systems are most preferred because they obviate the use of instrumentation for the reading of results. Membranes can be made of other natural or synthetic fibers, e.g., nylon.

## Claims

1. A kit for the semi-quantitative measurement, in a liquid sample, by competitive immunoassay, of a first member of a specific binding pair, the kit comprising a solid support
CHARACTERISED IN THAT
the support bears a reference area which provides a detectable signal in said immunoassay, and first and a second test area exposed to contact the sample, each test area comprising a different amount of said second or first member of said specific binding pair, whereby the intensity of the detectable signal from said reference area can be compared with the intensity of any detectable signals from said first and second test areas in the presence of an unknown quanity of the first member in said sample.

2. A kit for the determination, by competitive immunoassay, of the presence in a liquid sample of an amount greater than or equal to a predetermined, physiologically significant amount of a first member of a specific binding pair, the kit comprising a solid support
CHARACTERISED IN THAT
the support bears a reference area which provides a detectable signal in said immunoassay, and a test area comprising the second member of said specific binding pair, the test area being adapted to generate a detectable signal of lesser intensity with greater concentrations of said first member in said sample, said second member being present in the test area in an amount which, in said immunoassay, causes the test area to generate a detectable signal of significantly lower intensity that that of the reference area when said first member of said specific binding pair is present in said sample in an amount equal to or greater than a predetermined, physiologically significant amount, and which does not, in said immunoassay, cause the test area to generate a signal of significantly lower intensity from that of the reference area when said first member of said specific binding pair is present in said sample in an amount below said predetermined, physiologically significant amount.

3. A kit according to Claim 1 CHARACTERISED IN THAT the intensity of the signal generated by said first test area varies in substantially linear fashion when said sample contains said first member of said specific binding pair in an amount within a first range, and the intensity of the signal generated by said second test area varies in substantially linear fashion when said sample contains said first member of said specific binding pair in an amount within a second, greater range.

4. A kit according to Claim 1 or Claim 3 CHARACTERISED IN THAT said first member of said specific binding pair is equine progesterone.

5. A kit according to Claim 1 or Claim 2, CHARACTERISED BY including labeled first member of said specific binding pair when the test areas comprise second binding pair member, or labeled second member when the test areas comprise first binding pair member.

6. A kit according to Claim 1 or Claim 2 CHARACTERISED IN THAT said competitive immunoassay is an enzyme emmunoassay in which enzyme labeled first member of said specific binding pair competes with first member of said specific binding pair present in said sample for binding to second member of said specific binding pair on the solid support, the reference area containing antibody to said enzyme and being free from said second member of said specific binding pair.

7. A kit according to Claim 1 or Claim 2 CHARACTERISED IN THAT said competitive immunoassay is an enzyme immunoassay in which first member of said specific binding pair immobilized on the support competes with first member of said specific binding pair in said sample for binding to enzyme-labeled second member of said specific binding pair, the reference area containing antibody to said enzyme and being free from said first member of said specific binding pair.

8. A kit for the semiquantitative measurement, in a liquid sample, by sandwich immunoassay, of an analyte, the kit comprising a solid support
CHARACTERISED IN THAT
the support bears a test area comprising a first antibody specific for said analyte, and a first and a second calibration area, each of which contains a different amount of said analyte;
whereby the intensity of the detectable signal from said test area can be compared with the intensity of any detectable signals from said first and second calibration areas in the presence of an unknown quanity of the analyte in said sample.

9. A kit for the semiquantitive measurement, in a liquid sample, by sandwich immunoassay, of an analyte, the kit comprising a solid support, CHARACTERISED IN THAT
the support bears a first and a second test area, each of which comprises a different amount of a first antibody specific for said analyte, whereby the presence in said sample of said analyte in a first amount causes a substantial change in signal intensity in said first but not said second test area, and the presence in said sample of said analyte in a second, greater amount causes a substantial change in signal intensity in both first and second test areas.

10. A kit according to Claim 8 or Claim 9, CHARACTERISED BY including a second, labeled antibody specific for said analyte.

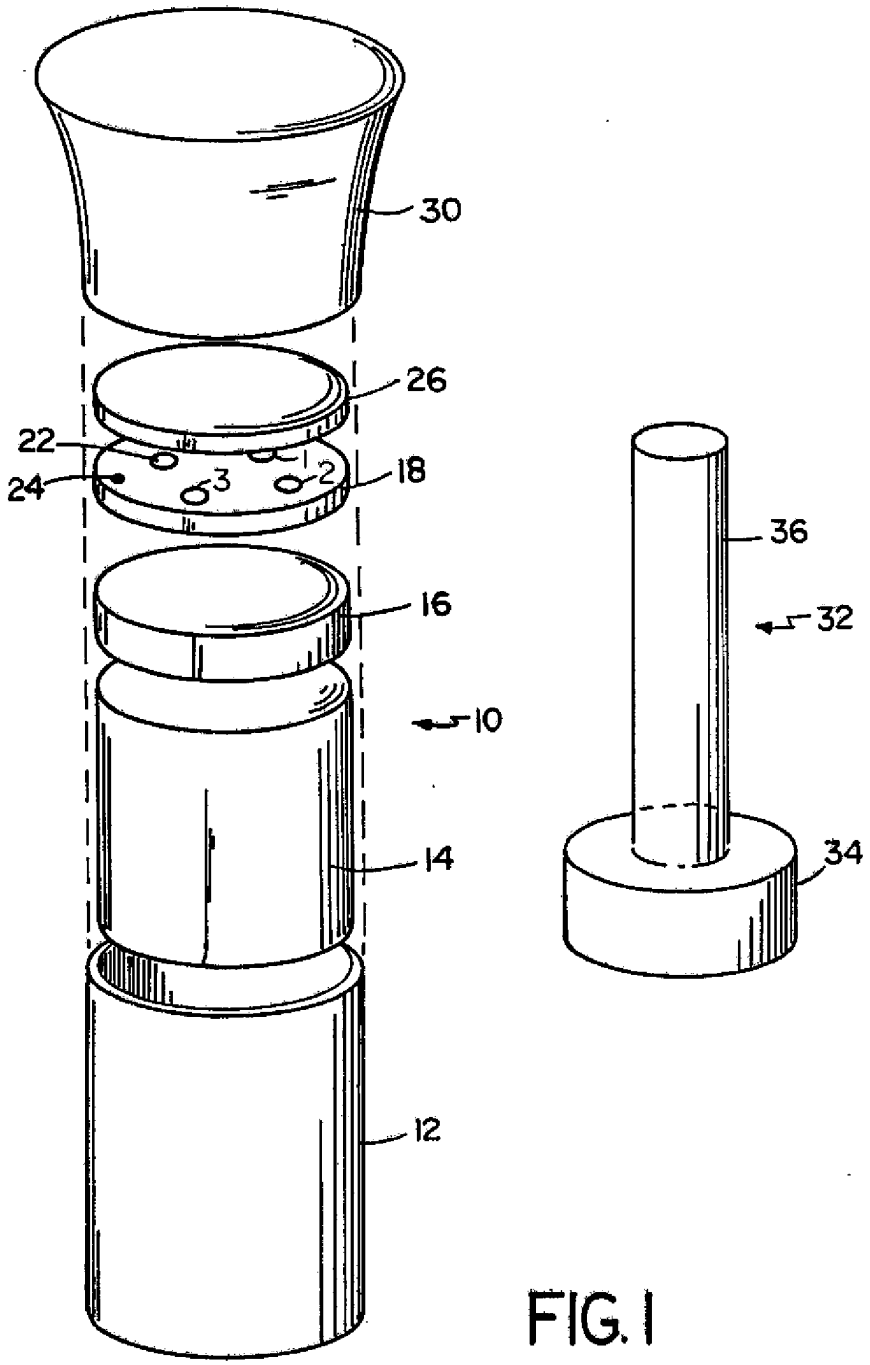


FIG. 1

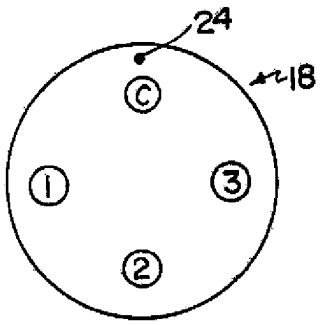


FIG.2

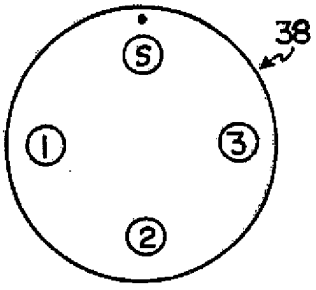


FIG.5

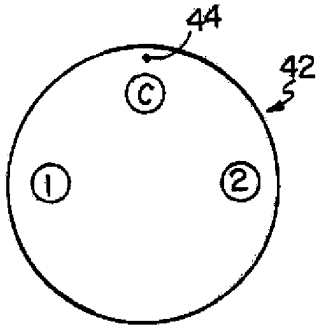


FIG.7

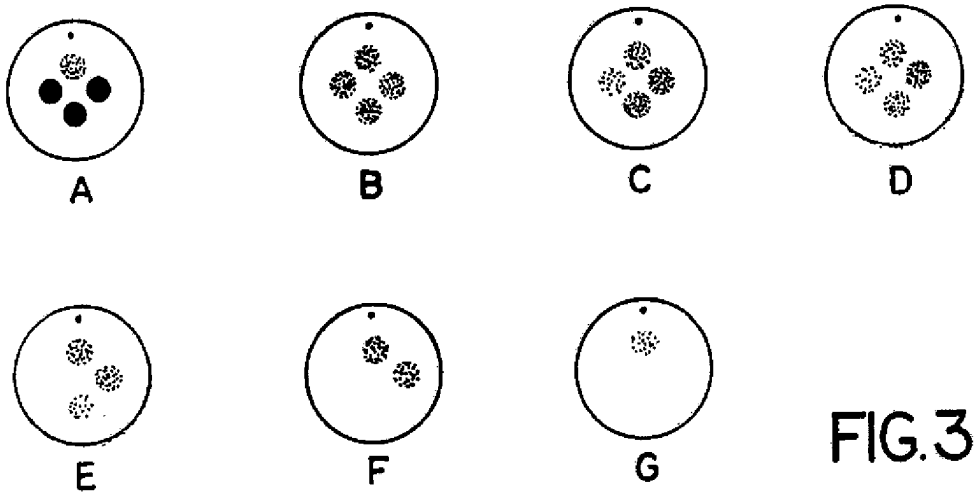


FIG.3

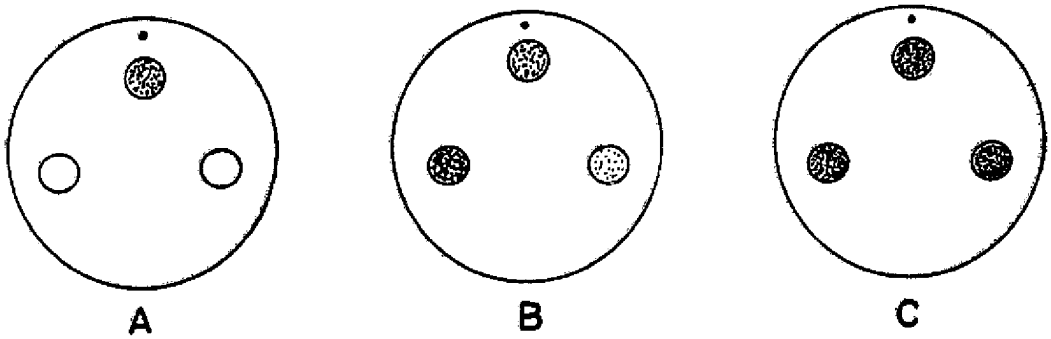


FIG.8

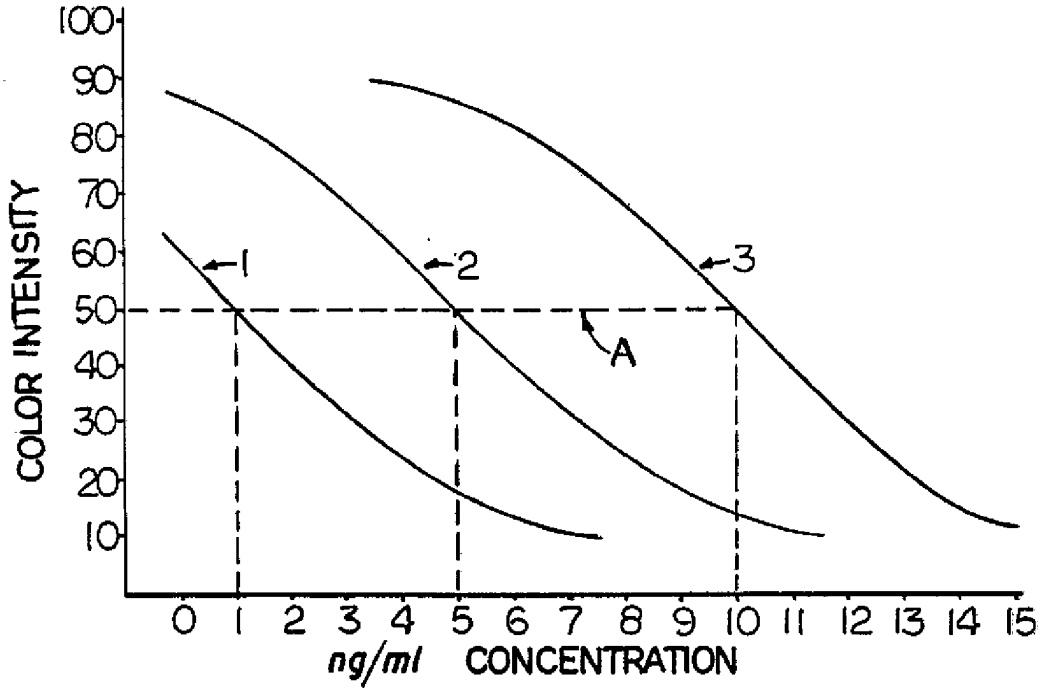
COLOR INTENSITY
100
90
80
70
60
50
40
30
20
10
1
2
3
A
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
ng/ml CONCENTRATION

FIG.4

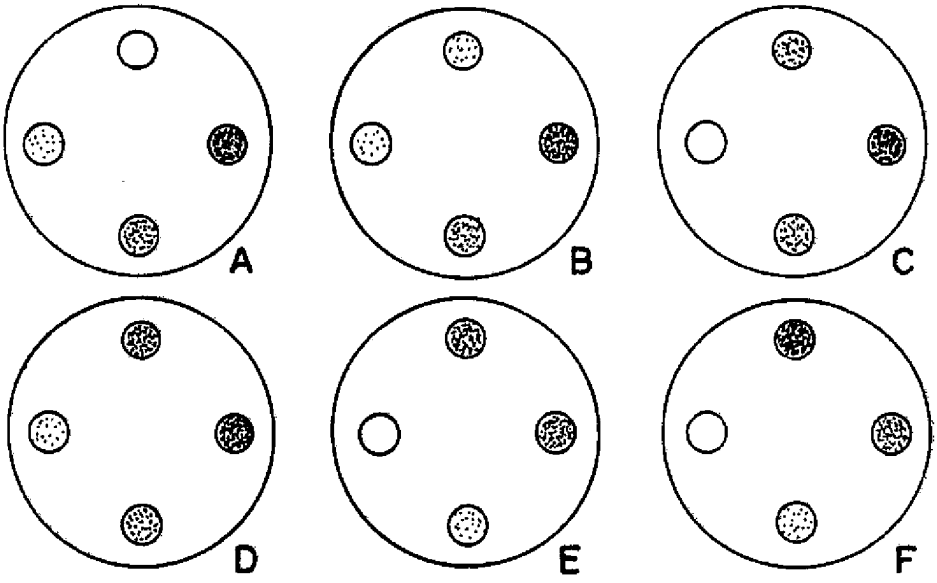
A
B
C
D
E
F

FIG.6